A UNIVERSITY LANDFILL SITE INVESTIGATION

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INTRODUCTION

The following is a description of the RCRA Facilities Investigation (RFI) that Brown and Caldwell Consultants (BCC) conducted at the University of Georgia, Athens (UGA) landfill in 1989. By a careful study of the existing site information, a well-focused approach to the RFI was developed and a favorable outcome achieved. The work was completed in one well-coordinated phase.

The site is located in northeast Georgia, south of Athens, Georgia. The landfill was an active repository for low-level radioactive and chemical wastes from 1969 until 1979. The site has not received waste material since 1979. The landfill has approximate dimensions of 250 feet by 150 feet. It consists of east-west trenches, approximately 8 to 12 feet deep. The landfill is equally divided into the eastern half, which received chemical waste, and the western half, which received low-level radioactive and biological wastes. An ephemeral/intermittent stream is located approximately 200 feet north of the landfill.

The purpose of the RFI was to validate any evidence of a release at the landfill, to determine the extent of potential contamination, and to obtain information on the nature and the extent of the release of contaminants. The need for interim corrective action, or a corrective measure study, was thus evaluated. This was accomplished through a series of data gathering and evaluating steps, including review of existing information and additional data obtained from soil and groundwater analyses. Based on the information gathered, an assessment of the impact of the contaminant release was formulated.

DATA COLLECTION

To obtain the necessary data during the RFI phase, the following tasks were performed and data was collected:

- Existing available data was collected and reviewed to more accurately characterize historical and existing site conditions at the UGA landfill.
- Available information was collected and evaluated to define the site physiography and hydrology to help evaluate potential exposure risks.
- Fifteen monitoring wells and ten piezometers were installed to verify site geology, define flow direction, and evaluate soil properties that could affect contaminant mobility.
- Information obtained from previous studies and from the installation of the monitoring wells and piezometers was used to characterize the site geology and hydrogeology to help evaluate contaminant mobility.
- Soil, groundwater, surface water, and sediment samples from the monitoring wells and stream were collected and analyzed to determine the primary groundwater and surface water pathways for release of landfill contaminants and the plume contaminant concentrations.
- A soil gas sampling survey, which included testing for methane and other volatile organic compounds (VOCs) in the hand-augered soil borings, was conducted at the UGA landfill to assist in determining the landfill dimensions and trench locations.

INVESTIGATION RESULTS AND INTERPRETATION

This section presents the various details of the RFI investigation and our interpretation of the RFI results.

Physiography and Hydrology

The UGA landfill is located in the Upland Georgia subsection of the Southern Piedmont physiographic section of Georgia. The topography of the landfill area is dominated by rounded, dome-shaped hilltops which slope toward a narrow stream valley. The landfill is located on the side of one of these hilltops. The general relief of the site varies from a maximum hilltop elevation of about 715 feet above mean sea level (AMSL) to an elevation of about 550 feet AMSL at the Middle Oconee River.

The basin which surrounds the landfill exhibits rolling hills and intermittent to year-round streams. The surface water runoff and groundwater baseflow from this basin discharge through one principal stream to the northwesterly located marsh, and subsequently to the Middle Oconee River. The stream, located at the northwest end of the smaller watershed in which the UGA landfill is situated, intercepts and collects flows from the entire basin.

Geology and Hydrogeology

The UGA drilling program showed residual soils, saprolite, and weathered bedrock above the parent bedrock contact. As the site drilling proceeded, the weathered rock exhibited increasing penetration resistance with depth. The weathered rock/bedrock contact was defined by drilling refusal. Using the field data obtained from the drilling program, a series of lines of geologic section were developed for the study area. The typical geologic sections demonstrate the amount of weathered rock overlying the unweathered or coherent bedrock to be about 70 feet near the landfill, down to about 50 feet near the stream. The bedrock surface generally reflects the surface hills and valleys.

The water table gradient beneath the landfill dips steeply to the northwest at a 0.05 gradient or 5 feet per 100 feet of horizontal distance. The water table then begins to flatten to a gradient of about 0.04. The water table gradient continues to diminish to about a 0.01 gradient toward the Middle Oconee River and adjacent marsh.

Aquifer Characteristics

Selected soil samples obtained from the well and piezometer boreholes were submitted to laboratory falling-head permeameter tests. The average permeability was determined to be 5×10^{-4} centimeters per second (cm/sec). The aquifer characteristics also were evaluated using standard "slug-test" methods. The average saturated aquifer thickness is about 30 feet in the basin water-table aquifer. The saturated aquifer thickness outside of the basin thins dramatically, particularly near monitoring well MW11. The average aquifer width in the basin is 650 feet across the longitudinal length of the groundwater flow system.

Groundwater flow through the watershed is defined by the aquifer permeability, porosity, hydraulic gradient, and cross-sectional area. The average pore velocity (average linear groundwater velocity) is calculated by multiplying the hydraulic conductivity by the hydraulic gradient and by the reciprocal of the effective porosity of the formation. The average pore velocity in the basin was determined to be 2.8×10^{-6} feet per second, or 0.24 feet per day.

The specific discharge of groundwater through the water-table aquifer can also be calculated. Effective porosity is not included in this equation as specific discharge is calculated for a full cross-sectional area of the aquifer.

The specific discharge was calculated to be 0.04 feet per day. The average linear velocity is used to conservatively calculate potential contaminant migration rates. The specific discharge is more often used in the groundwater volumetric flux calculation as an accepted, general estimate of potential groundwater flow through a given cross-sectional area. The groundwater flux moving through the basin, using the estimated cross-sectional area of the saturated portion of the aquifer, was calculated to be 0.01 ft^3/sec which is equivalent to 2.4×10^6 gallons of groundwater outflow from the basin per year.

Sampling and Analysis

Soil, groundwater, and surface water samples were collected during the 1989 investigation. The highest concentrations of contaminants were observed immediately downgradient from the landfill (MW4). The migration of contaminants was primarily to the northwest toward the on-site stream and the Middle Oconee River.

The constituents most frequently detected were chloroform, benzene, and methylene chloride. Chloroform was also found in two of the four stream grab samples collected during the subject investigation. The highest concentration of chloroform detected in the stream was 0.46 parts per million (ppm).

CONTAMINANT MIGRATION MECHANISMS AND PATHWAYS

The principal method of release and transport of contaminants at the UGA site was through groundwater movement. Other modes, including air and surface water, were evaluated but were not probable transport methods for this site. The transport of VOCs in groundwater is described below.

Groundwater Transport

Infiltration of precipitation at the UGA landfill site would contact the chemicals in the trenches, solubilizing the contaminants. These contaminants then may be transported to the water table aquifer and subsequently into the groundwater flow system. The solubilities of the principal contaminants vary from the highly soluble chloroform to the comparatively poorly soluble tetrachloroethylene (PCE).

In general, low Kow values (1×10^1 to 1×10^2) indicate good water solubility and moderate to poor adsorptivity. Values of Kow (greater than 1×10^2 and less than 1×10^4) are moderate to poorly soluble with moderate to high affinities for adsorption to soil particles. Values of Kow greater than 1×10^4 indicate hydrophobicity--there is a strong affinity for soil adsorption and little or no water solubility.

The water solubilities and degree of affinity for adsorption of the contaminants to soil particles at the UGA site are a major factor in the individual ability of these contaminants to move into and through the groundwater flow system. The contaminant solubility and associated adsorptivity determine the contaminant's general mobility in the site basin.

Exposure Pathways and Receptors

Exposure to the contaminants of concern identified at the UGA site requires migration of these chemicals from the landfill site to a specific point of use (ingestion, physical contact, etc.). The site at which exposure would occur is defined as the receptor location.

There are essentially three potential migration paths by which the landfill contaminants may travel to a receptor location. Contaminant migration could occur through volatilization and subsequent transport by wind or soil-air mechanisms. Overland transport of contaminants by windborne soil particles is also a potential migration pathway. Solubilization in the groundwater is an additional pathway. To summarize, potential migration paths are (1) wind-dispersed volatiles, (2) wind-dispersed contaminated soils, and (3) groundwater-dispersed and transported contaminants (advection and hydrodynamic dispersion).

No potential or known receptors are located within the migration path of the groundwater contaminants within the basin. Where contaminants could exit the site watershed, the potential receptors are limited to marshlands and the Middle Oconee River. Though the concentration of contaminants in the streamflow through the site has not been introduced, the impact of off-site transport of contaminants does not appear to be significant. The absence of any chloroform or other VOCs at a surface water sampling point located at the site stream (downgradient and northwest of the basin) supports the indication that groundwater baseflow to the on-site stream(s) generally dilutes site contaminants to levels less than the detection limit.

Contaminant Migration in the Water-Table Aquifer. As described, surface water infiltrates through the soil (unsaturated zone) and moves downward to the water table and along the groundwater flow system gradients. The water-table aquifer receives the downward moving water and any constituents which may be solubilized or carried in colloidal form in these waters.

The UGA basin and surrounding watershed streams converge approximately 400 feet beyond the outlet of the subject basin. West-northwest of the basin the water table flattens out; groundwater flows along a broader path to the west and northwest. This flow empties into the adjacent marshlands and the Middle Oconee River. The site itself is located immediately northwest of a surface and groundwater divide; thus, no flow occurs to the south-southeast from the site.

Exposure Model. No human receptor location was established within the subject basin. Thus, to fully examine the potential for exposure at the Middle Oconee River/marshland boundary, a hypothetical exposure model was completed for the most common contaminant, chloroform. Chloroform also exhibited the highest VOC concentrations measured in the groundwater within the basin. The other contaminants addressed in this section may be assumed to migrate within the groundwater flow system in a similar manner, but with varying degrees of attenuation and retardation.

Given the northwest trend of the water-table gradient (about 0.05 feet per foot) through the basin, the chloroform concentration at monitoring well MW9a was predicted by using the measured chloroform concentration in MW4 at the site. The Domenico-Palciauskas and Thorne and Rood equations for determining contaminant concentration at a downgradient receptor location were applied to this measured concentration and the measured and estimated site characteristics. The concentration of chloroform at the intermediate receptor location (MW9a) was predicted (solving by these equations) to be 2.66 ppm. The actual, measured chloroform concentration at MW9a was 0.26 ppm.

Factors not included in this calculation are natural in situ volatilization of chloroform (given the contaminant's high vapor pressure and volatility) which may effect a reduction in the predicted contaminant concentration. Also, dilution from recharge across the basin (about 6×10^6 gallons annually) with up to 2.4×10^6 gallons of annual groundwater throughflow (exclusive of groundwater baseflow to the basin streams) will effect a further reduced contaminant concentration. Dilution of the contaminant between MW4 at the site and MW9a downgradient of the site is not fully incorporated into this equation.

Biodegradation within the water table aquifer and enhanced attenuation on clay particles produce an additional reduction factor not included in these fate and transport calculations. Thus, a predicted chloroform value of 2.66 ppm at MW9a before allowing for enhanced attenuation, biodegradation, volatilization, and the full effects of dilution is acceptable agreement with the measured value of 0.26 ppm.

The proposed MCL of total trihalomethanes permitted in drinking water is 0.10 mg/L or 0.1 ppm. Total trihalomethane includes bromodichloromethane, dibromochloromethane, tribromomethane, and trichloromethane (chloroform). Chloroform is the only trihalomethane contaminant detected at MW9a. The level of chloroform (trihalomethane) was predicted at the receptor location (MW11) using the aforementioned equations. The predicted value of MW11 was 0.022 ppm, a value less than 1/4 of the proposed MCL.

Thus, the predicted exposure level defined by the most mobile, farthest-traveled, most common and highest concentration contaminant (chloroform) in the subject basin does not present a significant impact, in and of itself, on the Middle Oconee River and the adjacent marsh. If the dilution, alternation, biodegradation, and volatilization effects across the basin are also considered, the potential for impact of chloroform (as well as other VOCs) on the off-site groundwater flow system is further reduced.

SUMMARY

Using the 1989 analytical data obtained from the new wells and piezometers in conjunction with the results of the initial RCRA Facilities Investigation, the potential contaminant migration paths and mechanisms of transport at the landfill site were evaluated. The configuration of the site basin and the groundwater flow system provided the base on which potential contaminant exposure routes were defined.

The 1989 water table configuration generally reflects the surface topography and exhibits a well-defined groundwater flow system. Groundwater flow direction is contained within a 20-acre basin and only demonstrates west-northwesterly movement to the marshland and the Middle Oconee River downgradient of the basin outlet. Here, hydraulic gradients more gentle than those near the site are exhibited. Few or no contaminants were detected in those wells located at the most northwesterly limits of the basin. No VOCs were detected in the stream water leaving the site beyond the basin outlet.

An assessment of migration paths of the most significant contaminants in the basin addressed potential transport mechanisms and exposure routes. The groundwater flow system offers the only significant mechanism of transport and exposure of these contaminants.

Chloroform was chosen as the contaminant to be tracked through the basin due to its high concentration at the landfill site and its known carcinogenicity. A hypothetical concentration of chloroform was calculated at receptor location MW9a; this concentration was compared to the measured chloroform concentration at that point. Based on this measured concentration, the predicted chloroform concentration at MW11, located adjacent to the marshland northwest of the basin, also was calculated. The calculated level, 0.022 ppm, is far less than the proposed MCL for chloroform, which is 0.1 ppm.

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